

# **EARTHQUAKE HAZARD** across Europe

Where, how often and how strong  
does the earth shake in Europe?



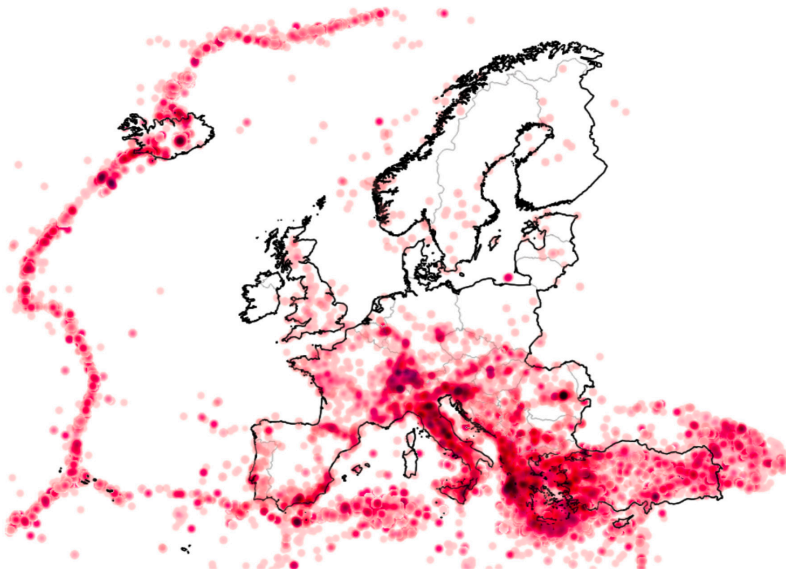
---

# Earthquakes in Europe

---

Every year, millions of earthquakes hit Europe. Most of these earthquakes are too small to be felt or to cause damaging effects, however, severe events occur periodically. Each time such a strong earthquake affects a region in Europe, it reminds us of the damage it can do to buildings and the environment, as well as the impact on people's well-being.

Earthquakes count as one of the deadliest natural hazards, and their occurrence can neither be prevented nor precisely predicted. However, thanks to earthquake hazard and risk assessments, we gain an improved understanding of where strong shaking is most likely to occur and what impact we should expect from future earthquakes.



**Figure 1:** Earthquakes from 1000 AD up to 2014 in Europe.

---

# What is earthquake hazard?

---

Earthquake hazard, also referred to as seismic hazard, describes the potential ground shaking due to future earthquakes. Ground shaking is the most relevant effect of an earthquake; however, it may also trigger secondary phenomena like tsunamis, landslides or rockfalls. Seismic hazard assessment is based on knowledge of past earthquakes, geology, and tectonics, as well as site response factors that may affect the strength of the shaking at any given location. Datasets representing these main ingredients are combined into an earthquake hazard model for Europe that can be used to estimate where earthquakes of different sizes may occur, how frequently they are expected to happen, and how probable certain levels of ground shaking due to earthquakes are.

## Earthquake catalogues



Information about earthquakes (e.g. location, magnitude and intensity) from 1000 AD up to 2014 has been compiled in so-called “earthquake catalogues”. Since the input to these catalogues is provided from many local or national seismic networks, the final earthquake catalogue needed to be harmonised to account for variations in the compilation of the different input catalogues.

## Geology & tectonics



Earthquakes occur due to the rupture of geological faults triggered by the motion of tectonic plates in the Earth’s crust. Information on the active faults helps us estimate the location and magnitude of future earthquakes, especially in regions where the earthquake catalogues are incomplete.

## Ground shaking models



The physics related to how seismic waves propagate from the hypocentre (where the fault starts to rupture) through the Earth’s crust, together with data from past earthquakes, allow us to estimate the ground shaking level at specific location due to an earthquake with a certain size.



---

# What is shown on the earthquake hazard map of Europe?

---

The earthquake hazard map shows the expected level of ground shaking at a specific location due to future potential earthquakes that might occur locally or at a greater distance. Ground shaking is expressed as Peak Ground Acceleration (PGA), normally given in the percentage of “g”, the Earth’s gravitational acceleration. The values displayed on the earthquake hazard map of Europe are based on the calculations of the 2020 European Seismic Hazard Model.

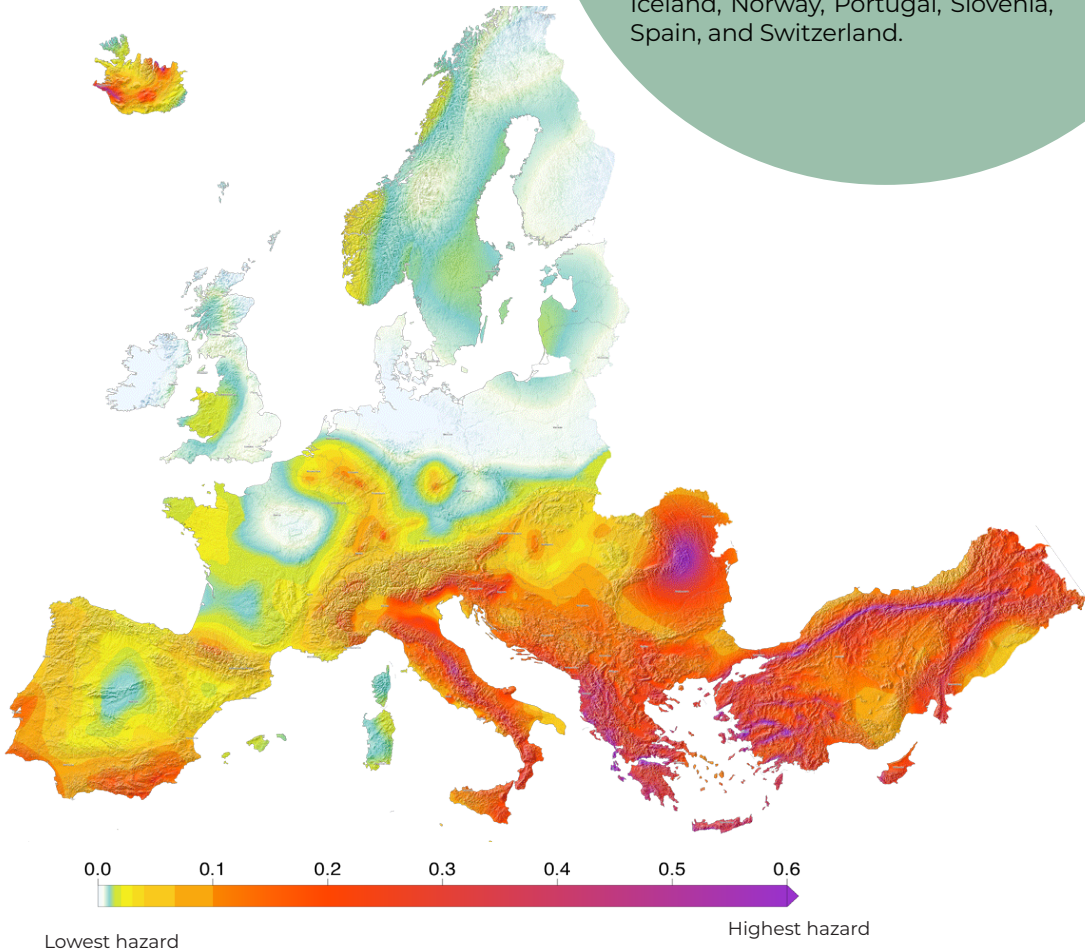
According to current design codes, earthquake-resistant residential or office buildings are designed to withstand expected ground shaking levels with a 10 % probability of being exceeded in a specific time interval (i.e. 50 years). This is the average expected lifetime of a standard residential building and can also be described as the ground shaking that is expected to be exceeded every 475 years (the so-called return period of the hazard).

On the earthquake hazard map of Europe, low hazard areas are coloured in white to green, moderate hazard areas in yellow to orange and high hazard areas in dark red to purple. Even in regions with a lower or moderate seismic hazard, earthquakes can occur at any location at any time.

## Regions with the highest earthquake hazard

Turkey, Greece, Albania, Italy, and Romania are the countries with the highest hazard in Europe, followed by the other Balkan Countries.

However, earthquake hazard is also considerable in some regions of Austria, Belgium, France, Germany, Iceland, Norway, Portugal, Slovenia, Spain, and Switzerland.



**Figure 2:** The earthquake hazard map of Europe based on the 2020 European Seismic Hazard Model.



---

# What can we learn from the European earthquake hazard model?

---

Earthquake hazard information is the basis of any mitigation decision aiming at reducing the potential effects of earthquakes and is, therefore, a prerequisite for assessing seismic risk. In science, models unite calculations that determine how something might develop in reality, e.g. the level of ground shaking due to earthquakes at different locations.

## **We can set new standards for the construction of buildings to make them more resilient against future earthquakes.**

Earthquake hazard models are primarily used in drafting seismic provisions. In Europe, Eurocode 8 are the standards recommended for earthquake-resistant construction and retrofitting buildings and structures to protect human lives, limit damages, and maintain functionally important civil protection structures. Specific hazard maps from the ESHM20 serve for the first time as an informative annex for the next version of Eurocode 8 to support the definition of seismic actions. Integrating earthquake hazard models in specific seismic design codes helps ensure that buildings respond appropriately to earthquakes by limiting the catastrophic damage that ground shaking can cause in the area where they are built. Note that the earthquake hazard values must always first be translated into the standards for earthquake-resistant design and cannot be used directly as a basis for construction.

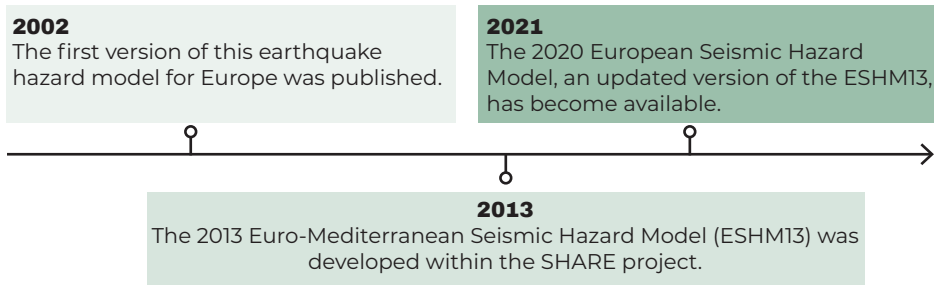
## **We can support the definition of effective transnational mitigation strategies.**

Most European countries routinely conduct, update and publish earthquake hazard assessments at the national level. Such models, when available, provide authoritative information to inform national, regional and local decisions related to developing seismic design codes and risk mitigation strategies. However, the underlying datasets of neighbouring countries are often not constructed consistently. An example is the varying treatment of uncertainties which can lead to inhomogeneous hazard assessments, making it difficult to use seismic hazard estimates across borders. The 2020 European Seismic Hazard Model is again fully harmonised across borders and offers comparable information, crucial to establishing effective transnational disaster mitigation strategies.

---

# What is new and innovative about the current version of the model?

---



Significant effort has been made to harmonise and extend the main underlying datasets:

- Thousands of earthquakes have been added to the earthquake catalogue, which now covers a wider range of magnitudes and includes an additional 1,000 historical events.
- Researchers added about 1,200 active faults to the active fault database, spanning over 90,000 km of mapped faults.
- New ground shaking models have been developed for Europe through the newly compiled recordings of strong ground shaking and enhanced metadata of 25,000 waveforms.
- State-of-the-art seismogenic source models capture the spatial and temporal pattern of earthquakes across Europe.
- Finally, researchers applied the most recent scientific knowledge to combine these datasets into computational seismic hazard models leading to an updated hazard model for Europe.

These advancements have resulted in more accurate estimates of earthquake hazard in Europe. In consequence, ground shaking levels for a given return period (i.e. 10% in 50 years) have been adjusted across Europe.



# More information



Learn more about earthquake hazard and risk across Europe at [www.efehr.org](http://www.efehr.org). Further information, explanatory material and access to technical reports, maps, data, and much more is available on this website.

# Acknowledgments

A core team of researchers from different institutions across Europe worked collaboratively in the framework of various projects to develop the 2020 European Seismic Hazard Model (ESHM20).

Many more have contributed to the development of ESHM20 by different means including data compilation and curation, knowledge exchange or by providing feedback at meetings and webinars. This has all been undertaken in close collaboration with the GEM Foundation and the European Plate Observing System (EPOS).

—→ Find a list with all names and institutions that have contributed at [www.hazard.efehr.org](http://www.hazard.efehr.org).

## Funding

The development of the 2020 European Seismic Hazard Model (ESHM20) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.s 730900, 676564 and 821115 of the projects [SERA](#), [EPOS-IP](#) and [RISE](#).



# Use of scientific products

Whenever making use of scientific products such as input files or when distributing visualizations of the 2020 European Seismic Hazard Model (ESHM20), please refer to:

Danciu L.<sup>1</sup>, Nandan S.<sup>1</sup>, Reyes C.<sup>1</sup>, Basili R.<sup>2</sup>, Weatherill G.<sup>3</sup>, Beauval C.<sup>4</sup>, Rovida A.<sup>2</sup>, Vilanova S.<sup>5</sup>, Sesetyan K.<sup>6</sup>, Bard P-Y.<sup>4</sup>, Cotton F.<sup>3</sup>, Wiemer S.<sup>1</sup>, Giardini D.<sup>1</sup> (2021) - The 2020 update of the European Seismic Hazard Model: Model Overview. EFEHR Technical Report 001, v1.0.0, <https://doi.org/10.12686/a15>

1. ETH Zurich, Switzerland
2. National Institute of Geophysics and Volcanology (INGV), Italy
3. GFZ German Research Centre for Geosciences, Germany
4. Institute of Earth Sciences (ISTerre), France
5. Advanced Technical Institute (IST), University of Lisbon, Portugal
6. Kandilli Observatory and Earthquake Research Institute, Bogazici University, Turkey

—→ Visit [www.hazard.efehr.org](http://www.hazard.efehr.org) to access earthquake hazard data and services.

## Rights and permission

Except where otherwise noted, all ESHM20 data and scientific products are released under the [Creative Commons BY 4.0](https://creativecommons.org/licenses/by/4.0/) license. These products can therefore be used for private, scientific, commercial and non-commercial purposes, provided adequate citation is added.



# The EFEHR Consortium

The European Facilities for Earthquake Hazard and Risk (EFEHR) is a non-profit network of organisations and community resources aiming to advance assessments of earthquake hazard and risk in the European-Mediterranean area.

EFEHR maintains and will further develop the earthquake hazard and risk model for Europe in collaboration with the GEM Foundation and the European Plate Observing System (EPOS).

More information: [www.efehr.org/efehr/about](http://www.efehr.org/efehr/about)



## Contact

EFEHR Office  
ETH Zurich  
Department of Earth Science  
Sonneggstrasse 5  
8092 Zurich, Switzerland  
Email: [efehr.hazard@sed.ethz.ch](mailto:efehr.hazard@sed.ethz.ch)



## Imprint

### Publisher

Swiss Seismological Service, ETH Zurich

### Concept, design and editorial

N. Valenzuela, M. Marti, S. Zaugg, L. Danciu, H. Crowley, J. Dabbeek and I. Dallo

### Legal notice

The sole responsibility lies with the authors. The European Union is not responsible for any use that may be made of the information contained therein.

© 2022, ETH Zurich holds the copyright on behalf of the EFEHR Consortium